Spatially Distributed CO_2, Sensible Heat, and Latent Heat Fluxes over the Southern Great Plains

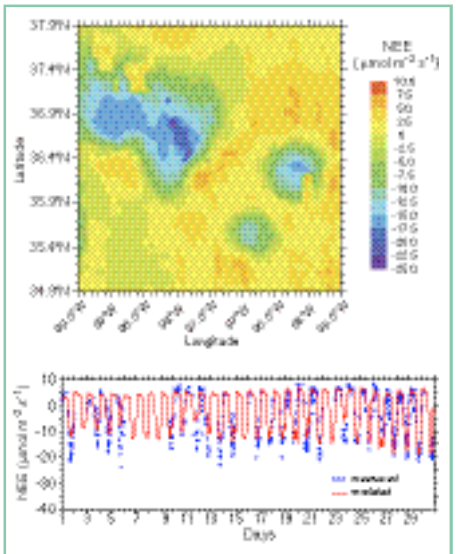
William J. Riley, Sébastien C. Biraud, Marc L. Fischer, Margaret S. Torn, and Joe A. Berry
Contact: William J. Riley, 510/486-5036, wjriley@lbl.gov

RESEARCH OBJECTIVES

We have developed a method to estimate regional-scale ecosystem CO_2 and energy exchanges at the Atmospheric Radiation Measurement Southern Great Plains (ARM-SGP) facility. This work addresses U.S. national goals of estimating regional CO_2 sources and sinks, and provides inputs to forward and inverse models.

APPROACH

Our method incorporates meteorological data from over 120 Oklahoma and Kansas Mesonet sites into a distributed land surface model (ISOLSM [Cooley et al., 2005; Riley, 2005; Riley et al., 2002], which is based on LSM1.0) of fluxes between ecosystems and the atmosphere. In addition to CO_2 and energy exchanges, ISOLSM predicts fluxes and pools of ^{18}O in CO_2 and H_2O and ^{13}C in CO_2. The meteorological datasets, compiled by ARM, contain fields for precipitation, radiation, wind speed, air temperature, and atmospheric pressure. Our interpolation provides meteorological input for ISOLSM at user-specified resolution across the ARM domain.



Top panel: Midday NEE at noon May 15, 2004, in the ARM-SGP domain. Bottom panel: Predicted and measured net CO_2 fluxes in a wheat field during May 2004.

We modified the land surface (vegetation) types in ISOLSM to correspond to the dominant land covers in the domain. Soil hydraulic characteristics are determined from the USGS STATSGO 1 km resolution soil map. We have tested ISOLSM in the dominant crop (winter wheat) in the SGP region [Riley et al., 2003] and calibrated to the dominant vegetation types with measurements made by portable 4 m systems comprised of a sonic anemometer and an open-path infrared gas analyzer (http://www.arm.gov/instruments/carbon.stm). Our preliminary calibration was accomplished by manipulating the maximum carboxylation rate and soil-organic-matter content associated with each vegetation type. Future work will improve on this approach by statistically minimizing errors in net ecosystem exchange (NEE) with these and other parameters.

ACCOMPLISHMENTS

Our results show that the interpolated meteorological fields are in good agreement with independent measurements in the area's dominant vegetation types. The bottom panel shows predicted and measured net CO_2 fluxes in a wheat field. Excellent agreement was also obtained for two other portable eddy flux sites (in pasture and sorghum fields).

SIGNIFICANCE OF FINDINGS

Typical midday NEE variations across the ARM-SGP domain can be large (up to 25 μmol m^{-2} s^{-1} (top panel), implying that estimating regional NEE requires accurate characterization of spatial heterogeneity in vegetation characteristics and meteorological forcing. Currently, the region is typically modeled as homogeneous cropland. Our approach allows us to quantify uncertainty in regional flux estimates associated with uncertainties in vegetation type, soil types, and spatial and temporal scaling of surface characterization and meteorological forcing. This work will benefit both "bottom-up" and "top-down" approaches to quantifying regional-scale surface CO_2 and energy exchanges.

RELATED PUBLICATIONS

Cooley, H.S., W.J. Riley, M.S. Torn, and Y. He, Impact of agricultural practice on regional climate in a coupled land surface mesoscale model. Journal of Geophysical Research-Atmospheres, 110, 2005. Berkeley Lab Report LBNL-56063.

Riley, W.J., Impact of the $\delta^{18}O$ value of near-surface soil water on the $\delta^{18}O$ value of the soil-surface CO_2 flux. Geochemica et Cosmochimica Acta (in press), 2005. Berkeley Lab Report LBNL-57348.

Riley, W.J., C.J. Still, M.S. Torn, and J.A. Berry, A mechanistic model of $H_2{}^{18}O$ and $C^{18}OO$ fluxes between ecosystems and the atmosphere: Model description and sensitivity analyses. Global Biogeochemical Cycles, 16, 1095–1109, 2002. Berkeley Lab Report LBNL-51234.

Riley, W.J., C.J. Still, B.R. Helliker, M. Ribas-Carbo, and J.A. Berry, ^{18}O composition of CO_2 and H_2O ecosystem pools and fluxes in a tallgrass prairie: Simulations and comparisons to measurements. Global Change Biology, 9, 1567–1581, 2003. Berkeley Lab Report LBNL-53019.

ACKNOWLEDGMENTS

This work was supported by the Director, Office of Science, Office of Biological and Environmental Research, Climate Change Research Division, Atmospheric and Radiation Measurements Program, of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.